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AUTHOR Cook, Nancy
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 INSTITUTION Washington Univ., Seattle.
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ABSTRACT

The Pacific Science Center developed a program to prevent mathematics avoidance in gifted females in fifth through seventh grade by increasing gifted girls' confidence in their ability to do mathematics and by increasing their mathematics ability. The Math for Gifted Girls curriculum included four general themes: innovative review of topics in mathematics known to present difficulties in early adolescence, such as fractions and percents; inclusion of topics not in regular mathematics curriculum, such as computer programing; a focus on spatial activities, such as improving one's ability to visualize three dimensional objects; and a focus on career awareness through the use of role models as well as discussion of the relation of mathematics to a variety of careers. Two components of the curriculum were an emphasis on problem solving and a sequence of activities from concrete to symbolic. Among findings from preliminary program evaluation were that there was little overall increase in girls' confidence, and much variation in response: that the strand on computers was the students' favorite and the strand on visualizing fractions was most useful; and all students agreed they had missed too much school and had too much homework to make up. (SBH)

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MATH FOR GIFTED GIRLS

Presentation

to

Washington Educational Research Association/
Northwest Gifted Child Association

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Nancy Cook, Ph.D.
115 Miller Hall DQ-12
University of Washington
Seattle, Washington 98195
(206) 543-1847

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Intellectually capable females continue to avoid mathematics in high school. Upon entrance to the university these young females find that this lack of mathematics training drastically curtails their career options. Four years of high school mathematics are required for admission to 15 of the 20 fields of undergraduate study at the University of California at Berkeley. In 1972, 8% of the first year females, compared to 58% of the first year males, had taken four years of high school mathematics. That is, 92% of the entering females did not qualify for admission to 75% of the undergraduate fields of study due to a lack of mathematical training (Sells, 1973). Remick and Miller (1976) report similar findings. Four years of high school mathematics are required for 11 of the 16 fields of undergraduate study at the University of Washington. In 1976, 22% of the entering females compared to 44% of the entering males had taken four years of high school mathematics. The problem persists today. The recent National Assessment of Education Progress (NAEP) included data on mathematics participation by sex. While there were no sex differences in participation in algebra I and geometry, significantly more males than females participated in trigonometry and calculus (NAEP, 1979). Similar data are reported in both the Women in Mathematics study (Armstrong, 1980) and the Equals Bay Area mathematics participation data (Kreinberg, note 1).

Mathematics avoidance cuts across all ethnic boundaries; females, regardless of ethnic origin, lack the mathematical background that permits freedom in choice of career. While 31% of Caucasian and Asian females entered the

University of Washington with four years of high school mathematics, only 13% of Black and Hispanic females entered with such training (Remick and Miller, 1976). Sells (note 2) reports similar findings.

Intellectually capable girls -- gifted girls -- avoid mathematics. Bright girls tend to self-select themselves out of advanced high school mathematics courses (Haven, 1972). Because of this avoidance of mathematics, the magnitude of the sex differences in mathematics achievement increases, rather than decreases, with giftedness (Fox, 1976). The Study of Mathematically Precocious Youth annually conducts a talent search, the results of which consistently show increasing sex differences in mathematics achievement as a function of mathematics scores. That is, as the score increases, the proportion of girls decreases (Keating, 1976). "Gifted boys out-perform gifted girls on difficult precollege-level tests of mathematical ability, and the differences in performance are particularly striking at the upper ends of the distributions" (Fox, 1976, p. 184).

What are the factors associated with mathematics avoidance? Until the pioneering work of Fennema and Sherman (1977), it had been assumed that females were less capable of learning mathematics. However, Fennema and Sherman (1977; 1978) documented that females who choose to study mathematics do as well as males. The problem is that more capable females than males choose not to study mathematics. Similar results are reported by De Wolf (1978). She reported no sex differences in mathematics achievement if amount of mathematics studied is controlled for. While both Fennema and Sherman and De Wolf found no sex differences in problem solving when amount of mathematics studied is controlled, recent data show otherwise. Both the 1979 NAEP results and the Women in Mathematics study (Armstrong, 1980) reveal

no sex differences in mathematics achievement in all areas but one -- problem solving. Both sets of data show males to be better problem solvers than females.

The impact of problem-solving ability on mathematics avoidance is not well known; however, there are data that suggest at least an indirect relation. Problem-solving skills and attitudes toward mathematics are significantly correlated (Fennema and Sherman, 1977; 1978). In addition, mathematics participation (avoidance) and attitudes toward mathematics are significantly correlated (Armstrong, 1980; Lantz, 1980). Therefore, it would not be surprising to find problem-solving skills and mathematics avoidance correlated.

The two attitudinal factors consistently reported to be correlated with mathematics avoidance are usefulness and confidence (Fennema, Reyes, Perl, and Konsin, 1980; Lantz, 1980; Armstrong, 1980). Males are more aware than females of the role mathematics will play in their future career choice. Due, in part, to this lack of awareness of the usefulness of mathematics, females tend not to study mathematics. In addition, males appear to have more confidence in their ability to do mathematics, and this lack of confidence on the part of females also contributes to their mathematics avoidance.

The perception of the usefulness of mathematics appears to be the affective factor most associated with the continued study of mathematics in gifted girls. The best predictor of gifted high school females' participation in mathematics courses is their perception of how useful mathematics will be to their future career choice (Haven, 1971). In addition, Fox (1976) found that failure to attend to the social interests of girls

could lead to increasing sex differences in mathematics achievement of gifted students.

Males and females do not attribute success to the same factors. Males tend to attribute success in general to internal, stable causes such as ability, while females tend to attribute success to external, unstable causes such as luck. Attribution of failure is just reversed; males tend to attribute failure to luck, and females tend to attribute failure to ability (Deaux, 1976; Bar-Tal and Frieze, 1977). While boys and girls attribute both success and failure in mathematics to internal causes, males attribute success to internal factors significantly more than do females (Fennema, et al., 1980).

In summary, females, including gifted females, avoid mathematics. The continued study of mathematics is necessary to assure full choice of career options, and data suggest that when females are aware of the usefulness of mathematics in relation to career choice they are more apt to continue to study mathematics.

Mathematics for Gifted Girls

The Pacific Science Center received monies from the Northwest Area Foundation to develop a program which has as its goal the prevention of mathematics avoidance in gifted females. Since research has shown that awareness of the usefulness of mathematics is the foremost factor associated with mathematics avoidance in gifted females, the primary goal of the program was to increase gifted girls' awareness of the usefulness of mathematics in relation to career choice. The program had, in addition, two other goals: to increase gifted girls' confidence in their ability to do

mathematics, and to increase their mathematics ability.

In order to insure a multi-ethnic participant population, Seattle, rather than surrounding suburban areas, was selected as the target population. Since mathematics avoidance begins to surface in the early adolescent, and the goal of the program focused on its prevention, participants were selected from grades five through seven. The target population within these grades were those girls who scored at the 85th percentile or above in language arts and at the 55th percentile and below in mathematics on the last city-wide administered standardized test. Two hundred seventy-one girls from 56 schools were identified as possible participants.

In order to maximize the potential for social interaction among the participants both during the program and when the girls returned to their school settings, the number of participating schools was limited to six in order to have at least four girls from every participating school. All 56 schools had large numbers of Caucasian girls who met the criteria; therefore, those six schools which had the largest number of ethnic minority students meeting the criteria were identified as the target schools. There were 61 girls in these six schools who met the criteria. Letters inviting participation in the program were sent to all 61 girls. In addition, phone contact with each potential participant was attempted; 54 contacts were made. Of these, 53 girls indicated an interest in the program, and 50 girls actually participated.

Due to the large numbers of girls who wanted to participate in such a program, Math for Gifted Girls offered two sessions, a 1979 Summer Program and a 1980 Winter Program. Thirty girls, including 10 non-white girls, from

six schools participated in the 1979 Summer Program, and 20 girls, including five non-white girls, from three schools participated in the 1980 Winter Program.

Active recruitment of teachers was unnecessary. As word of the project spread, interested teachers volunteered, resulting in an exceptionally qualified and dedicated staff, who as a team brought together expertise on mathematics from a variety of disciplines. The teaching team included a University of Washington Mathematics Educator, the head of a private high school's mathematics department, a biologist who is also a professional musician and a practicing school psychologist who is a former mathematics teacher. In addition to the teaching staff, the Director of Gifted Education Programs at the Pacific Science Center and a practicing school psychologist conducted two meetings for parents.

The Math for Gifted Girls curriculum included four general themes:

- 1) innovative review of those topics in mathematics known to present difficulties to early adolescents, such as fractions and percents;
- 2) inclusion of topics not in the regular mathematics curriculum, such as computer programming;
- 3) a focus on spatial activities, such as improving one's ability to visualize three-dimensional objects; and
- 4) a focus on career awareness through the use of role models as well as discussion of the relation of mathematics to a variety of careers.

In order to present a curriculum that was not fragmented yet presented a variety of activities, the above four themes were integrated and sequenced into a total curriculum. A calendar of activities for the six-day program is included. While many of the activities are self-explanatory, the rationale behind some must be detailed.

MATH FOR GIFTED GIRLS
CALENDAR OF ACTIVITIES
WEEK 1

	DAY 1	DAY 2
9:30	Instant Investigations Graphing	Instant Investigations Graphing
10:00	<i>GROUP 1*</i> Computers Logic Games	<i>GROUP 1</i> Computers Simulation
10:30	<i>GROUP 2</i> Spring Balances Introduction	<i>GROUP 2</i> Logic Games Practice
11:00	<i>GROUP 1</i> Spring Balances Introduction	<i>GROUP 1</i> Logic Games Practice
11:30	<i>GROUP 2</i> Computers Logic Games	<i>GROUP 2</i> Computers Simulation
12:00	Lunch	Lunch
12:30	Explore the Science Center	<i>GROUP 1</i> Spring Balances Graphing
1:00	<i>GROUP 1</i> Logic Games Strategies	<i>GROUP 2</i> Visualizing Fractions Addition & Subtraction
1:30	<i>GROUP 2</i> Spring Balances Construction	<i>GROUP 1</i> Visualizing Fractions Addition & Subtraction
	<i>GROUP 1</i> Spring Balances Construction	<i>GROUP 2</i> Spring Balances Graphing
2:00	<i>GROUP 2</i> Logic Games Strategies	
	Discussion	Discussion

* Girls had free choice of what group to go into at any time throughout the program

MATH FOR GIFTED GIRLS

CALENDAR OF ACTIVITIES

WEEK 2

	DAY 3	DAY 4
9:30	Instant Investigations Logic Puzzles	Instant Investigations Logic Puzzles
10:00	GROUP 1 Computers Programming	GROUP 1 Body Density % Body Fat
10:30	GROUP 2 Calculators Operations Review	GROUP 2 Calculators Percents
	GROUP 1 Calculators Operations Review	GROUP 1 Calculators Percents
	GROUP 2 Computers Programming	GROUP 2 Body Density % Body Fat
11:30	Lunch	Lunch
12:00	GROUP 1 Physical Fitness Body Fat	Visit to Physical Fitness Laboratory
12:30	GROUP 2 Density Small Objects	
1:00	GROUP 1 Density Small Objects	
1:30	GROUP 2 Physical Fitness Body Fat	
2:00	Discussion	Discussion

MATH FOR GIFTED GIRLS
CALENDAR OF ACTIVITIES
WEEK 3

	DAY 5	DAY 6
9:30	Rotating Groups Density	Instant Investigations 3-D Constructions
10:00	Relate concrete to symbolic	
10:30	Visualizing Fractions Multiplication	Leave for UW Dr. Estella Leopold Age dating material through pollen counts
11:00	Spatial Tasks 2-D Rotations	
11:30	Lunch	
12:00	GROUP 1 Calculators Percents & Rates GROUP 2 Spatial Tasks 3-D Imagery	Lunch & Cake Problem
1:00	GROUP 1 Spatial Tasks 3-D Imagery GROUP 2 Calculators Percents & Rates	Program Evaluation & Discussion
1:30		
2:00	Discussion	

Three topics known to present difficulties for adolescents are fractions, percents and rates, and graphing. Two of these topics, fractions and graphing, include a spatial component and thereby can be integrated into the focus on improving spatial skills. Note that the entire sequence on spring balances leads to a final component focused on graphing. The third topic, percents and rates, can be approached through activities focused on physical fitness, a topic of vital interest to the adolescent female.

Adolescent females are most concerned about their bodies; in particular, they are concerned with body fat. This interest in body fat was used to get at body density, which was then related to density in general. The calculation of body fat was just one of many exercises in determining one's physical fitness. This unit, which proved to be very popular, had as its main objective a review of percents and rates!

The target schools all have computers available for classroom use, yet most of the participants were avoiding the computer. Therefore, special attention was focused on increasing each girl's knowledge of and skills in using the computer. The focus on computers came early in the program to enable the participants to practice their new found skills throughout the remainder of the program. The Pacific Science Center has ten computer terminals and as the girls' skills increased, they began to arrive early in order to use the computers before the Pacific Science Center opened to the public! This component of the program was by far the most popular, which is interesting in light of the fact that some programs to get girls interested in computers are meeting with mixed success.

The sequencing is critical. The girls first work in teams at the

terminals attempting to discover optimum strategies for the games 'What's My Number' and 'Trap Me'. 'What's My Number' involves discovering the secret number which is between 1 and 100. One can ask questions of the form "Is it greater than 50?" to which the computer replies either yes or no. Theoretically, the number can be identified in seven questions. 'Trap Me' is a more sophisticated variation. After working at the terminal, the strategies of the two games are discussed and analyzed, and more advanced games are introduced. On Day 2, the girls simulate the workings of a computer. The staff believes it is this simulation that frees the girls from the "fear of the computer" and enables them to realize that they are in control. This belief, based only on observation and anecdotal material needs to be further investigated. The simulation is followed on Days 3 and 4 with individual help in programming both analytical and figural problems.

Girls appear to perform less well than boys on tasks involving spatial components, and this lack of spatial ability is highly correlated with poor performance in mathematics (Fennema and Sherman, 1977). Cook and Kersh (note 3) have developed a program for improving performance on spatial tasks, and a mini-version of the program was incorporated into the Math for Gifted Girls curriculum. Again, the sequencing is important. The work began with two-dimensional (2-D) tasks of visual imagery, tasks involving no mental movement of the created image, followed by tasks involving mental rotations of 2-D objects. Then visual imagery of three-dimensional (3-D) objects was introduced, followed by mental rotations of 3-D objects. The final task involved constructing 3-D objects from a series of 2-D representations.

Opportunities for discussion on career aspirations presented themselves

frequently during class discussions, during lunch, and in connection with the continual questions regarding the personal lives of the staff! Not only was the entire staff female, to insure ample role models, but field trips involved meeting female scientists on the job.

There were two components of the curriculum that are not obvious from the calendar of events: a focus on problem solving and a sequence of activities from concrete to symbolic. Problem solving was integrated into all components, either through the curriculum itself, as with the logic games and the Instant Investigations, or through the employment of a problem-solving methodology, as in the case of improving spatial skills. All activities included the manipulation of concrete objects, ranging from pattern blocks to computer terminals. The emphasis was on learning by doing. A common complaint associated with this strategy of instruction is that while the doing is fun and the students like it, the doing is never related to the symbolic, to paper and pencil mathematics. The relation between the concrete and the symbolic was built into the curriculum through both the sequencing of the activities and the discussions surrounding the activities.

The parents of the girls were invited to participate in two evening sessions. The first session was held before Day 1 of the program. The purpose was to acquaint the parents with the program and its staff. The rationale for the program was explained as well as a description of how their daughters were chosen. A second session was held near the end of the program to share with the parents the activities in which their daughters had been engaged. Parents were invited to share ideas and suggestions for increasing their daughter's interest in mathematics as well as ideas and suggestions for improving the program.

While no formal evaluation of the 1979 Summer Program was undertaken, evaluation of the 1980 Winter Program is currently being conducted. Only preliminary results can be reported. The program had three objectives: to increase gifted girls' awareness of the usefulness of mathematics, to increase gifted girls' confidence in their ability to do mathematics, and to increase gifted girls' ability to do mathematics. Each will be discussed followed by a discussion of the participants' evaluation of the program.

The Fennema-Sherman Attitude Toward Mathematics Scales (Fennema and Sherman, 1976) were used to assess both Usefulness and Confidence. The girls were visited at their schools during the week prior to the program at which time the first assessments were made. A second assessment was made during the last day of the program. The pre-assessment of Usefulness ranged in scores from 2.59 to 4.17 on a scale of 1 (little awareness) to 5 (much awareness). The mean rating was 3.24. The post-assessment ranged from 2.50 to 5, with the mean rating being 3.54. The increase in Usefulness as measured by the pre- post-assessments was significant at the .01 level. The Fennema-Sherman Scales are counterbalanced in regard to positively and negatively stated items. Of interest is the fact that the greatest increase in Usefulness was seen on the negatively stated items, such as "Taking math is a waste of time." While increase occurred on positive items such as "I will use math in many ways," even greater increase was seen in the reduction of the magnitude of response to the negative items.

The responses to the pre-assessment of Confidence ranged from 1.75 to 3.83 on a 1 (little confidence) to 5 (much confidence). The mean response was 3.92. The responses on the post-assessment ranged from 1.33 to 4.0, with the mean response at 3.98. There was little overall increase in

confidence, and much variation in response. Some girls increased in confidence, others showed a decrease as measured by the assessments. There could be two explanations for the observed results. The girls could have actually decreased in confidence. This would not be surprising. Even though these girls did not perform well on standardized tests of mathematics, many were receiving A's and B's on classwork. The emphasis in the program was on conceptual aspects of mathematics as well as on problem solving, two components of mathematics in which one cannot rely on short term memory alone. These girls when confronted with such mathematics might have begun to be aware of their inabilities and actually decreased in confidence. If, indeed, this was the case, a program spread over a longer period of time is mandated in order to allow staff the time to rebuild and nurture the girls' confidence. However, another explanation is more feasible. The girls, when first assessed, could not afford to let the staff "know of their shortcomings" -- their lack of confidence -- and answered the questions as "they thought they should." As the rapport between the staff and the girls developed, the girls could afford to be themselves and honestly confess to a "lack of confidence" (as they did in class as the program progressed).

25 data
2001-10-16
1979-10-16

Seattle School District assesses students' abilities in the fall and the spring of each year using the California Achievement Test (CAT). The spring results are being analyzed. When the data are available the 1979 Fall CAT mathematics scores will be compared to the 1980 spring CAT scores for both the participants and for a matched control group. The controls were matched to the participants on both mathematics and language arts scores as well as grade level. The difference in increase for each group will be statistically analyzed.

On the last day of the program the girls were asked to evaluate their experiences. The strand on computers was their "favorite," and the strand on visualizing fractions was "most useful." When asked what else should have been included or what changes should be made, they responded with "more trips." They all agreed they had missed too much school and had too much homework to make up, but all except two indicated no hesitation in participating in another program if invited to do so.

NOTES

1. N. Kreinberg. Equals summary findings. Unpublished manuscript, 1980.
2. L. Sells. Math avoidance in women and minorities. Unpublished data, 1980.
3. N. Cook & M.E. Kersh. Improving Mathematics Abilities and Attitudes Through Spatial Training. Project funded by FIPSE, 1978-80.

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